June 1999

Chemistry 30

Grade 12 Diploma Examination

Alberta
EDUCATION

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Chemistry 30

Grade 12 Diploma Examination

Description

Time: 2.5 h. This examination was developed to be completed in 2.5 h; however, you may take an additional 0.5 h to complete the examination.

This is a **closed-book** examination consisting of

- 44 multiple-choice and 12 numerical-response questions, each of equal value, worth 70% of the examination
- 2 written-response questions of equal value, worth 30% of the examination

This examination contains sets of related questions

A set of questions may contain multiple-choice and/or numerical-response and/or written-response questions.

When required, a grey bar will be used to indicate the end of a set.

A chemistry data booklet is provided for your reference.

Note: *The perforated pages at the back of this booklet may be torn out and used for your rough work.* ***No marks*** *will be given for work done on the tear-out pages.*

Instructions

- You are expected to provide your own scientific calculator.
- Use only an HB pencil for the machine-scored answer sheet.
- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- Read each question carefully.
- Consider all numbers used in the examination to be the result of a measurement or observation.
- When performing calculations, use the values of the constants provided in the data booklet. Do **not** use the values programmed in your calculator.
- If you wish to change an answer, erase **all** traces of your first answer.
- Do not fold the answer sheet.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
- Now turn this page and read the detailed instructions for answering machine-scored and written-response questions.

Multiple Choice

- Decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

Example

This examination is for the subject of

A. chemistry
B. biology
C. physics
D. science

Answer Sheet

● Ⓑ Ⓒ Ⓓ

Numerical Response

- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- If an answer is a value between 0 and 1 (e.g., 0.25), then be sure to record the 0 before the decimal place.
- **Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.**

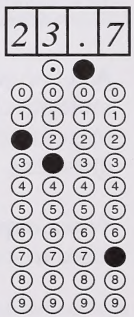
Examples

Calculation Question and Solution

The average of the values 21.0, 25.5, and 24.5 is _____.
(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Average = (21.0 + 25.5 + 24.5)/3
= 23.666
= 23.7 (rounded to three digits)

Record 23.7 on the answer sheet →



Correct-Order Question and Solution

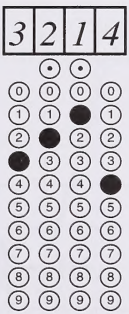
When the following subjects are arranged in alphabetical order, the order is _____.

1 physics
2 chemistry
3 biology
4 science

(Record **all four digits** of your answer in the numerical-response section on the answer sheet.)

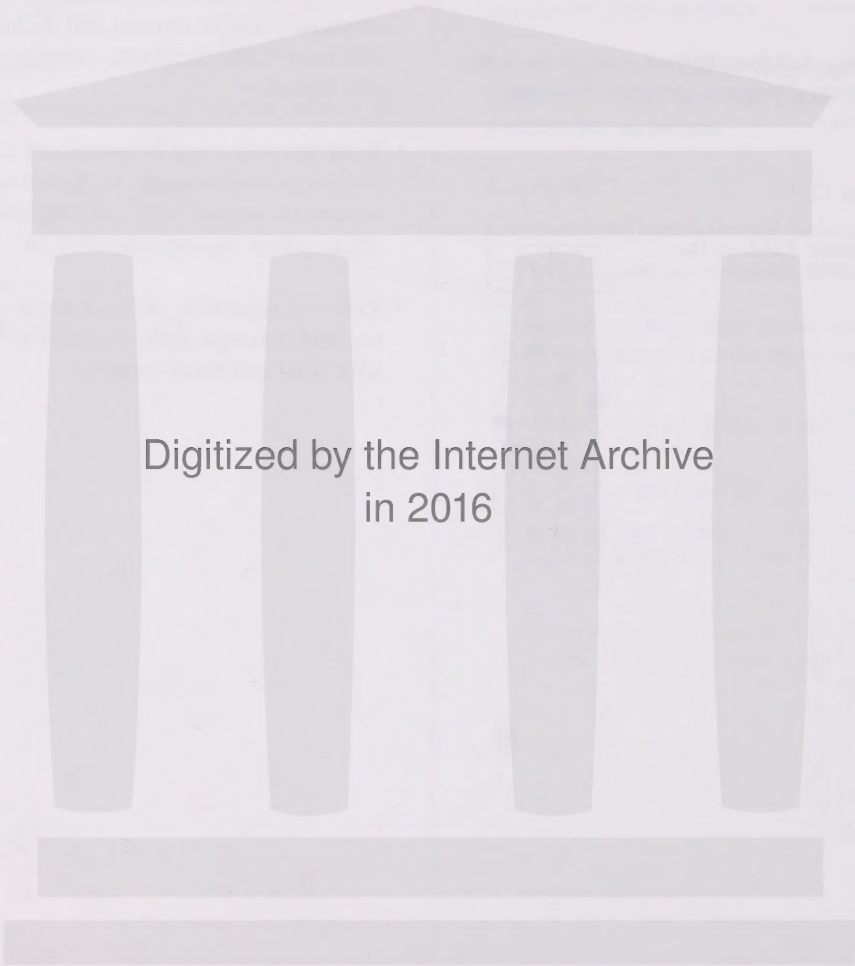
Answer 3214

Record 3214 on the answer sheet →



Written Response

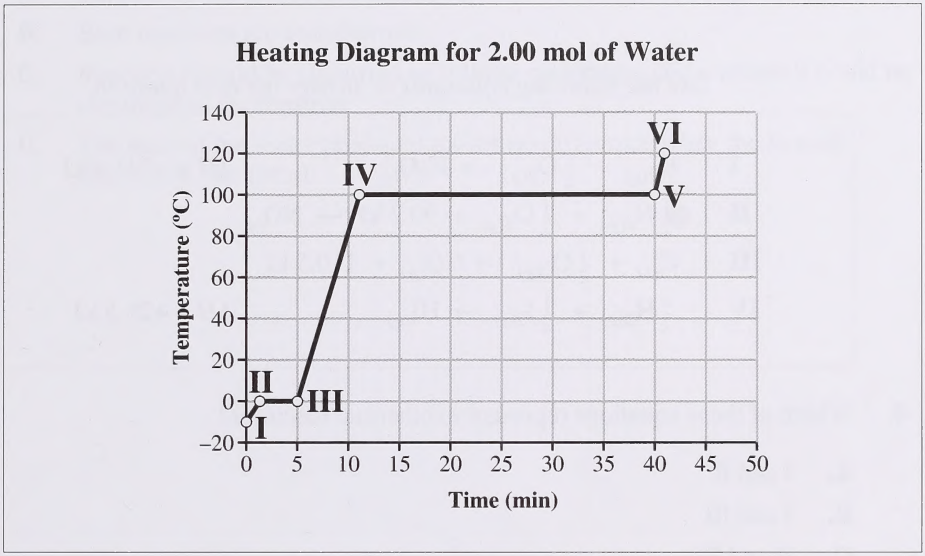
- Write your answers in the examination booklet as neatly as possible.
- For full marks, your answers must address **all** aspects of the question.
- Descriptions and/or explanations of concepts must be correct and include pertinent ideas, diagrams, calculations, and formulas.
- Your answers must be presented in a well-organized manner using complete sentences, correct units, and significant digits where appropriate.
- Relevant scientific, technological, and/or societal concepts and examples must be identified and made explicit.



1. Radiant energy from the Sun is stored by plants. This energy is released when plant material undergoes a

   A. phase change
   B. nuclear change
   C. chemical change
   D. formation reaction

Use the following information to answer the next question.



2. The region on the diagram where liquid water is undergoing a change primarily in kinetic energy is between

   A. II and III
   B. III and IV
   C. IV and V
   D. V and VI

3. The reason that dynamite releases a great amount of heat energy when it explodes is that the

   A. products have more potential energy than the reactants in this endothermic reaction

   B. reactants have more potential energy than the products in this endothermic reaction

   C. products have more potential energy than the reactants in this exothermic reaction

   D. reactants have more potential energy than the products in this exothermic reaction

Use the following equations to answer the next question.

I	$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(g)}$	$\Delta H = -241.8$ kJ
II	$\frac{1}{2}N_{2(g)} + \frac{1}{2}O_{2(g)} + 90.2\text{ kJ} \rightarrow NO_{(g)}$	
III	$C_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{(g)} + 110.5\text{ kJ}$	
IV	$\frac{1}{2}H_{2(g)} + \frac{1}{2}I_{2(s)} \rightarrow HI_{(g)}$	$\Delta H = +26.5$ kJ

4. Which of these equations represent exothermic reactions?

   A. I and II

   B. I and III

   C. II and IV

   D. III and IV

Use the following reactions to answer the next question.

Glucose Reactions

I $C_6H_{12}O_{6(aq)} + 6\,O_{2(g)} \rightarrow 6\,H_2O_{(l)} + 6\,CO_{2(g)}$

II $C_6H_{12}O_{6(s)} + 6\,O_{2(g)} \rightarrow 6\,H_2O_{(g)} + 6\,CO_{2(g)}$

5. Which of the following statements describes the reactions above?

A. Carbon is reduced in both reactions.

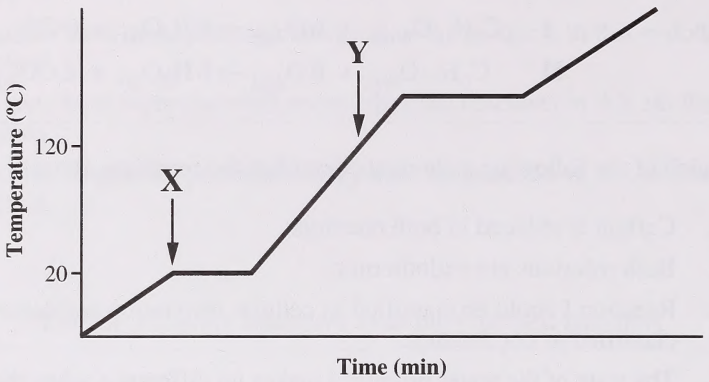
B. Both reactions are endothermic.

C. Reaction I could be classified as cellular respiration and reaction II could be classified as combustion.

D. The state of the water produced makes no difference when the heat of reaction is calculated.

Use the following information to answer the next question.

Heating of 11.2 g of an Unknown Compound



Characteristic Properties

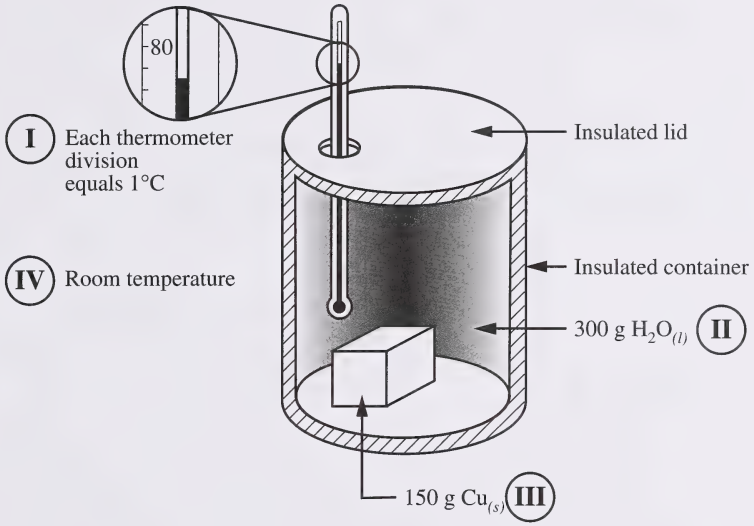
1 Melting point
2 Boiling point
3 Specific heat capacity of liquid
4 Molar heat of fusion
5 Molar heat of vaporization

6. In order to calculate the amount of energy required to heat the unknown compound from point X to point Y, the characteristic properties listed above that must be known, in addition to the information given in the graph, are properties

A. 1 and 4
B. 2 and 5
C. 3 and 4
D. 3 and 5

Use the following information to answer the next question.

The calorimeter shown in this diagram can be used to determine the specific heat capacity of copper. The calorimeter was at room temperature before the heated copper sample was added.



7. Two variables that could have been manipulated in this calorimetry experiment are

A. I and III
B. I and IV
C. II and III
D. II and IV

Numerical Response

1. A 24.6 g sample of molten copper at its melting point is lowered into a calorimeter containing 200 g of water. As soon as solidification is complete, the sample is quickly removed. The temperature of the water in the calorimeter rises from 11.23°C to 17.34°C. In this experiment, the molar heat of solidification for copper is –_____ kJ/mol.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

8. The molar heat of solution for $NaOH_{(s)}$ is -44.6 kJ/mol. If 25.0 g of $NaOH_{(s)}$ is dissolved in water in a calorimeter, the heat released inside the calorimeter is

A. 27.9 kJ

B. 71.4 kJ

C. 1.12 MJ

D. 1.78 MJ

9. When 24.0 g of carbon and 10.0 g of hydrogen are placed in a bomb calorimeter and reacted according to the equation $3\,C_{(s)} + 4\,H_{2(g)} \rightarrow C_3H_{8(g)} + 103.8$ kJ, the maximum amount of heat liberated by this reaction is

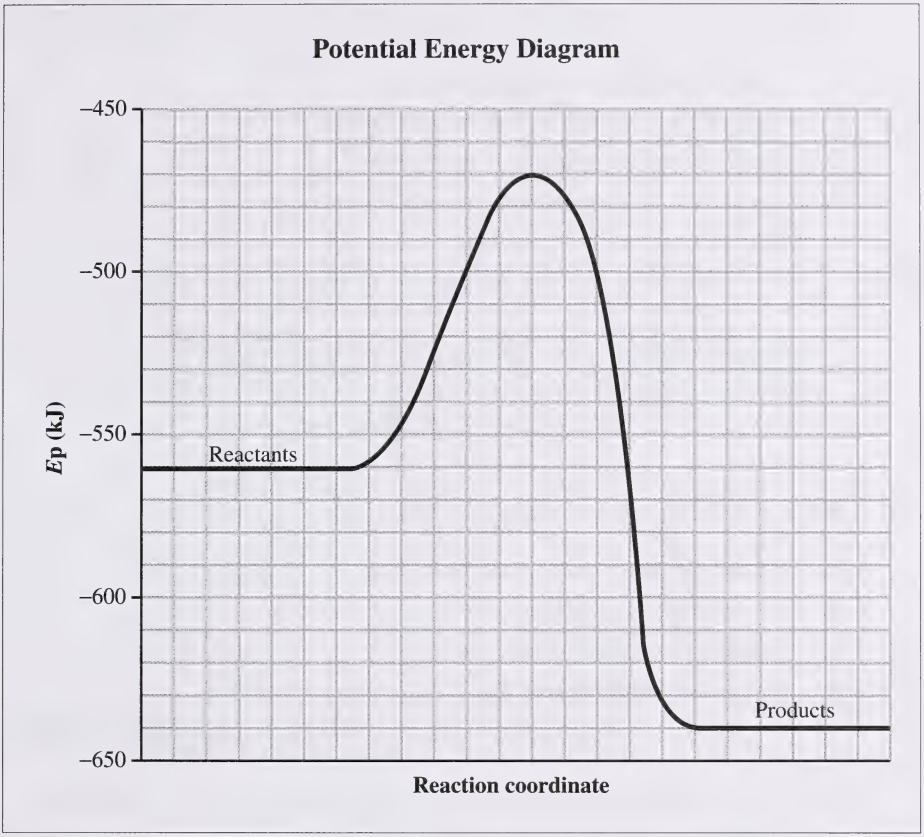
A. 69.1 kJ

B. 128 kJ

C. 257 kJ

D. 619 kJ

Use the following diagram to answer the next question.



10. The potential energy change for this reaction is

A. +170 kJ

B. +90 kJ

C. –80 kJ

D. –170 kJ

11. In the reaction $2\,Sn_{(s)} + O_{2(g)} \rightarrow 2\,SnO_{(s)}$, tin is

A. reduced and the reaction is exothermic
B. reduced and the reaction is endothermic
C. oxidized and the reaction is endothermic
D. oxidized and the reaction is exothermic

Use the following information to answer the next question.

A farmer noticed a white substance around the scratches on his zinc-coated steel grain bins. His daughter, who had just completed Chemistry 30, correctly told him that the zinc was being oxidized.

12. In the process of being oxidized, the zinc

A. gained electrons to produce more $Zn_{(s)}$
B. lost electrons and became $Zn^{2+}_{(aq)}$
C. gained protons to produce $Zn^{2+}_{(aq)}$
D. lost protons and became $Zn_{(s)}$

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13. In the balanced redox reaction equation

$3\,Cu_{(s)} + 2\,NO_3^-{}_{(aq)} + 8\,H^+{}_{(aq)} \rightarrow 3\,Cu^{2+}{}_{(aq)} + 2\,NO_{(g)} + 4\,H_2O_{(l)}$,

the oxidation number of nitrogen

A. decreases by 3
B. increases by 3
C. increases by 2
D. decreases by 6

14. In a reaction, $Sn^{2+}_{(aq)}$

A. will undergo oxidation when combined with $Pb(NO_3)_{2(aq)}$
B. act as a reducing agent when combined with $Ni_{(s)}$
C. always act as an oxidizing agent
D. act as an oxidizing agent when combined with $Cd_{(s)}$

15. A redox reaction occurs when an iron nail is placed in a solution of copper(II) sulphate. Elemental copper begins to form, and the colour of the solution changes. In this reaction, the reducing agent is

A. $Fe_{(s)}$
B. $Cu_{(s)}$
C. $Fe^{2+}_{(aq)}$
D. $Cu^{2+}_{(aq)}$

Use the following equations to answer the next question.

1 $HSO_3^-{}_{(aq)} + HCO_3^-{}_{(aq)} \rightarrow H_2CO_{3(aq)} + SO_3^{2-}{}_{(aq)}$

2 $C_6H_{12}O_{6(aq)} + 6\,O_{2(g)} \rightarrow 6\,CO_{2(g)} + 6\,H_2O_{(l)}$

3 $Ni^{2+}_{(aq)} + Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + Ni_{(s)}$

4 $Co^{2+}_{(aq)} + 2\,Fe^{2+}_{(aq)} \rightarrow 2\,Fe^{3+}_{(aq)} + Co_{(s)}$

5 $6\,CO_{2(g)} + 6\,H_2O_{(l)} \rightarrow C_6H_{12}O_{6(aq)} + 6\,O_{2(g)}$

Numerical Response

2. Match the equations, as numbered above, with the corresponding descriptions listed below.

A biological redox reaction carried out in a plant cell but not in an animal cell _____ (Record in the **first** column)

A biological redox reaction carried out in both animal and plant cells _____ (Record in the **second** column)

A spontaneous, non-biological redox reaction _____ (Record in the **third** column)

A non-spontaneous, non-biological redox reaction _____ (Record in the **fourth** column)

(Record your answer in the numerical-response section on the answer sheet.)

16. The voltage of an electrochemical cell is +0.20 V. If one of the half-reactions is the reduction of $Cu^{2+}_{(aq)}$, then the other half-reaction that occurs could be

A. $2\,I^-_{(aq)} \rightarrow I_{2(s)} + 2\,e^-$

B. $S_{(s)} + 2\,H^+_{(aq)} + 2\,e^- \rightarrow H_2S_{(aq)}$

C. $H_2S_{(aq)} \rightarrow S_{(s)} + 2\,H^+_{(aq)} + 2\,e^-$

D. $I_{2(s)} + 2\,e^- \rightarrow 2\,I^-_{(aq)}$

Use the following information to answer the next question.

To prevent it from contaminating the air, chlorine gas can be reacted as represented by the **unbalanced** equation

$$Cl_{2(g)} + S_2O_3^{2-}{}_{(aq)} + H_2O_{(l)} \rightarrow SO_4^{2-}{}_{(aq)} + H^+_{(aq)} + Cl^-_{(aq)}$$

17. The balanced oxidation half-reaction for this change is

A. $H_2O_{(l)} + S_2O_3^{2-}{}_{(aq)} \rightarrow SO_4^{2-}{}_{(aq)} + 4\,e^- + 2\,H^+_{(aq)}$

B. $Cl_{2(g)} + 2\,e^- \rightarrow 2\,Cl^-_{(aq)}$

C. $5\,H_2O_{(l)} + S_2O_3^{2-}{}_{(aq)} \rightarrow 2\,SO_4^{2-}{}_{(aq)} + 10\,H^+_{(aq)} + 8\,e^-$

D. $5\,H_2O_{(l)} + S_2O_3^{2-}{}_{(aq)} + 4\,e^- \rightarrow 2\,SO_4^{2-}{}_{(aq)} + 10\,H^+_{(aq)}$

Numerical Response

3. When the equation $V_2O_{5(s)} + Mn_{(s)} \rightarrow VO_{(s)} + MnO_{2(s)}$ is balanced using the lowest whole number coefficients, the coefficient of

$V_2O_{5(s)}$ is _____ (Record in the **first** column)

$Mn_{(s)}$ is _____ (Record in the **second** column)

$VO_{(s)}$ is _____ (Record in the **third** column)

$MnO_{2(s)}$ is _____ (Record in the **fourth** column)

(Record your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

The following materials are used by Chemistry 30 students in laboratory work.

1	electrodes	**5**	thermometer
2	insulated containers	**6**	electrolytes
3	pH paper	**7**	external circuit
4	porous boundary	**8**	buret

Numerical Response

4. The materials necessary to construct an operational voltaic cell are, in numerical order, _____ , _____ , _____ , and _____ .

(Record your **four-digit answer** in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

In a laboratory, a student obtained the following results when testing, under standard conditions, reactions between various metals and their corresponding ions.

	$Ga_{(s)}$	$Fe_{(s)}$	$Zn_{(s)}$	$Mg_{(s)}$
$Ga^{3+}_{(aq)}$	–	×	✓	✓
$Fe^{2+}_{(aq)}$	✓	–	✓	✓
$Zn^{2+}_{(aq)}$	×	×	–	✓
$Mg^{2+}_{(aq)}$	×	×	×	–

Key

✓ denotes reaction
× denotes no reaction
– denotes no test performed

18. The reduction potential of the $Ga^{3+}_{(aq)}$ could be

A. –0.53 V
B. –1.41 V
C. +1.21 V
D. +1.92 V

19. A net cell potential value that would represent a spontaneous reaction is

A. –1.05 V
B. –0.08 V
C. 0.00 V
D. +0.15 V

20. In an experiment, a student used 11.33 mL of $H_2O_{2(aq)}$ to titrate a 17.00 mL sample of acidified 8.0×10^{-3} mol/L $KMnO_{4(aq)}$. If $Mn^{2+}{}_{(aq)}$ is one of the products, then the concentration of the $H_2O_{2(aq)}$ is

A. 1.2×10^{-2} mol/L
B. 1.5×10^{-2} mol/L
C. 3.0×10^{-2} mol/L
D. 6.0×10^{-2} mol/L

21. Sacrificial metals may be used to protect pipelines, septic tanks, and ship propellers. A metal that could be used as a sacrificial anode to protect iron is

A. magnesium
B. tin
C. lead
D. silver

22. Electrolysis of $MgCl_{2(aq)}$ will not produce magnesium metal because

A. $Cl^-{}_{(aq)}$ is a stronger oxidizing agent than $Mg^{2+}{}_{(aq)}$
B. $H_2O_{(l)}$ is a stronger reducing agent than $Mg^{2+}{}_{(aq)}$
C. $H_2O_{(l)}$ is a stronger oxidizing agent than $Mg^{2+}{}_{(aq)}$
D. $Cl^-{}_{(aq)}$ is a stronger reducing agent than $Mg^{2+}{}_{(aq)}$

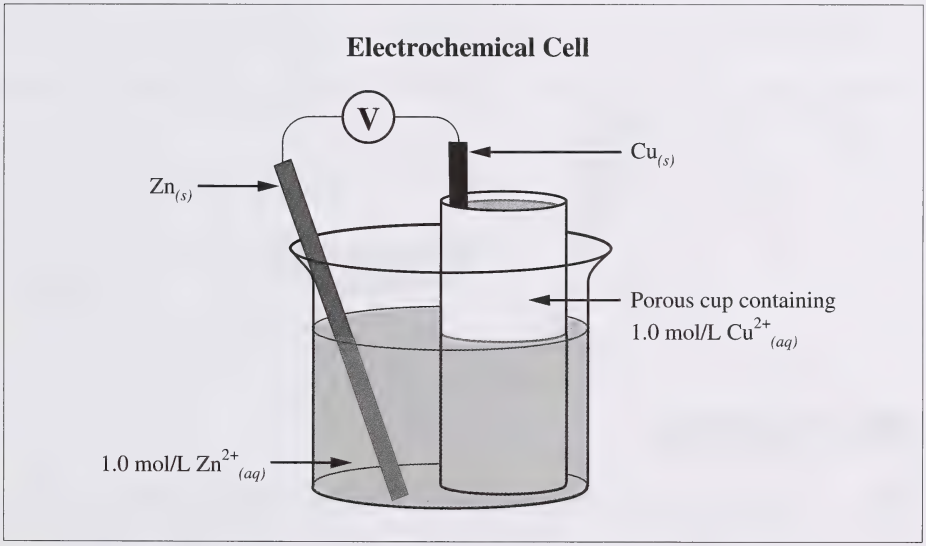
23. If the $Cu^{2+}_{(aq)} / Cu_{(s)}$ reduction half-reaction was assigned a reduction potential value of 0.00 V for an electrode potential table, then the $Ni^{2+}_{(aq)} / Ni_{(s)}$ half-reaction on that table would have a reduction potential value of

A. +0.26 V
B. +0.08 V
C. –0.26 V
D. –0.60 V

24. When chlorine gas is bubbled through a sodium iodide solution, the solution

A. becomes reddish-brown because iodide ions are oxidized
B. becomes reddish-brown because iodide ions are reduced
C. becomes reddish-brown because chlorine is oxidized
D. stays colourless

Use the following diagram to answer the next question.



25. For this cell, the potential is

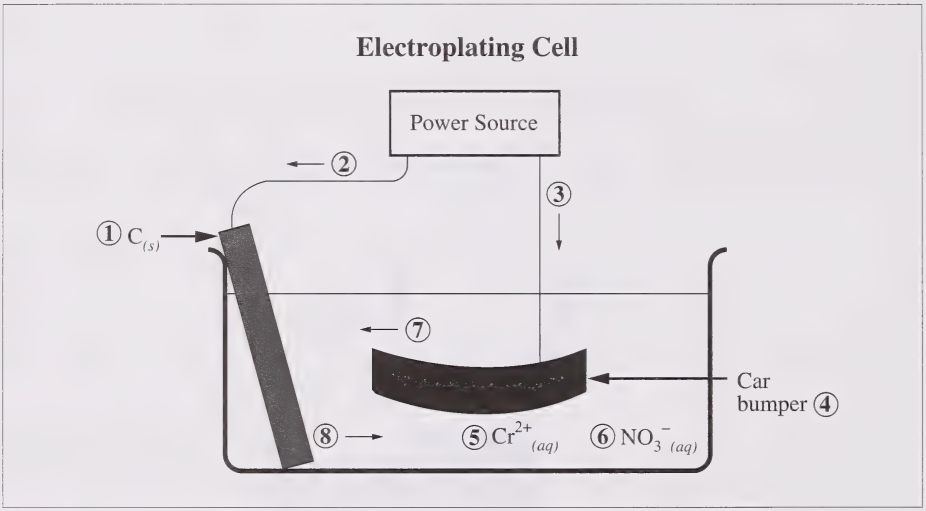
A. +1.10 V
B. +0.42 V
C. –0.42 V
D. –1.10 V

Chromium plating of objects, such as iron car bumpers, to prevent corrosion actually involves the plating of three different metals in three separate electrolytic cells. The first cell contains a solution of a copper salt, the second a solution of nickel salt, and the third a solution of chromium salt.

26. During the nickel stage of the electroplating process, the nickel(II) ions

A. gain electrons, and metal is deposited on the anode
B. gain electrons, and metal is deposited on the cathode
C. lose electrons, and metal is deposited on the anode
D. lose electrons, and metal is deposited on the cathode

Use the following diagram to answer the next question.



Numerical Response

5. Use the numbers that identify the parts of the electroplating cell in the diagram above to complete the statements below.

The cathode is identified by _____ (Record in the **first** column)
The electron movement is identified by _____ (Record in the **second** column)
The cation movement is identified by _____ (Record in the **third** column)
The anion is identified by _____ (Record in the **fourth** column)

(Record your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next two questions.

A chromium electroplating cell needs to operate at a current of 2000 A to plate 112 g of chromium onto a car bumper.

Numerical Response

6. In order to plate the bumper, the number of moles of chromium(II) ions that must react in the cell is _____ mol.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

*Use your recorded answer for **Numerical Response 6** to answer **Numerical Response 7.****

Numerical Response

7. In order to plate the bumper, the cell must operate for _____ min.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

***You can receive marks for this question even if the previous question was answered incorrectly.**

27. A property that is **not** consistent with the behaviour of water is that water is able to

A. act both as an acid and a base in proton transfer reactions
B. absorb 241.8 kJ when one mole of water vapour is formed from its elements
C. act as an oxidizing agent or reducing agent in electrolytic cells
D. react with acids to produce hydronium ions

28. Chemical systems reach equilibrium when

A. no reaction is occurring
B. the rates of forward and reverse reactions become equal
C. the mass of products equals the mass of reactants
D. the number of moles of products equals the number of moles of reactants

Nitrogen forms a number of oxides. Examples include $NO_{(g)}$, $NO_{2(g)}$, $N_2O_{(g)}$, and $N_2O_{5(g)}$.

Numerical Response

8. The oxidation number of nitrogen in each compound listed above is, respectively, _____ , _____ , _____ , and _____ .

(Record your **four-digit answer** in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

Nitrogen monoxide, an atmospheric pollutant, can be formed in automobile engines as represented by the equation

$$N_{2(g)} + O_{2(g)} + 180.4\ kJ \rightleftharpoons 2\,NO_{(g)}$$

29. The amount of $N_{2(g)}$ at equilibrium can be increased by

A. increasing the pressure by reducing the volume
B. removing $NO_{(g)}$
C. adding $O_{2(g)}$
D. decreasing the temperature

Use the following information to answer the next two questions.

The equilibrium $2\,NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$ is established when 0.734 mol of $NO_{2(g)}$ at 25°C is placed in a 2.00 L flask.

30. The initial concentration of the $NO_{2(g)}$ was

A. 0.734 mol/L
B. 0.367 mol/L
C. 0.184 mol/L
D. 1.47 mol/L

*Use your recorded answer for **Multiple Choice 30** to answer **Numerical Response 9.****

Numerical Response

9. The equilibrium concentration of $N_2O_{4(g)}$ is 0.125 mol/L. The equilibrium constant for the reaction is _____.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

***You can receive marks for this question even if the previous question was answered incorrectly.**

Use the following information to answer the next question.

When 20.0 mL of 0.10 mol/L solutions of $NaHCO_{3(aq)}$, $NaHS_{(aq)}$, $NaOCl_{(aq)}$, and $NaH_2BO_{3(aq)}$ were each reacted with 20.0 mL of 0.10 mol/L $HBrO_{(aq)}$, the following positions of equilibrium were established.

$$HCO_3^-{}_{(aq)} + HBrO_{(aq)} \rightleftharpoons \text{favours reactants}$$
$$HS^-{}_{(aq)} + HBrO_{(aq)} \rightleftharpoons \text{favours reactants}$$
$$OCl^-{}_{(aq)} + HBrO_{(aq)} \rightleftharpoons \text{favours reactants}$$
$$H_2BO_3^-{}_{(aq)} + HBrO_{(aq)} \rightleftharpoons \text{favours products}$$

31. Based on these positions, the placement of $HBrO_{(aq)}$ on the Relative Strengths of Acids and Bases chart is

A. below boric acid
B. above carbonic acid
C. below hypochlorous acid
D. above hydrosulphuric acid

Use the following equilibrium to answer the next question.

$$\underset{\mathbf{1}}{HSO_4^-{}_{(aq)}} + \underset{\mathbf{2}}{HCOO^-{}_{(aq)}} \rightleftharpoons \underset{\mathbf{3}}{HCOOH_{(aq)}} + \underset{\mathbf{4}}{SO_4^{2-}{}_{(aq)}}$$

Numerical Response

10. Match each acid or base in the forward reaction, as numbered above, with the corresponding term given below.

acid _____ (Record in the **first** column)
conjugate base _____ (Record in the **second** column)
base _____ (Record in the **third** column)
conjugate acid _____ (Record in the **fourth** column)

(Record your answer in the numerical-response section on the answer sheet.)

32. If the following solutions are of equal concentration, then which of them would be the best conductor of an electric current?

A. $CH_3COOH_{(aq)}$

B. $H_2CO_{3(aq)}$

C. $HF_{(aq)}$

D. $HCN_{(aq)}$

33. Most plants grow best in soil with a pH between 6 and 7. Higher or lower pH values prevent them from absorbing essential nutrients. Plants can absorb phosphorus in the form of $H_2PO_4^-{}_{(aq)}$. In basic soil, $H_2PO_4^-{}_{(aq)}$ could be converted to

A. $P_{4(s)}$

B. $PO_4^{3-}{}_{(aq)}$

C. $H_3PO_{4(aq)}$

D. $HPO_4^{2-}{}_{(aq)}$

34. The amphiprotic (amphoteric) species that reacts with bromothymol blue to produce a yellow colour is

A. $NaHSO_{4(aq)}$

B. $NaHCO_{3(aq)}$

C. $NaOCl_{(aq)}$

D. $H_2O_{(l)}$

Rainwater is acidic because it contains dissolved atmospheric $CO_{2(g)}$ that occurs naturally. It may also contain air pollutants, $NO_{x(g)}$, and $SO_{x(g)}$ from industrial sources.

35. If each of the following components of acid rain is of equal concentration, then which of them would have the lowest pH?

A. $HNO_{3(aq)}$
B. $HNO_{2(aq)}$
C. $H_2SO_{3(aq)}$
D. $H_2SO_{4(aq)}$

Use the following information to answer the next question.

A sample of rainwater is poured into five test tubes. A different indicator is added to each test tube. Four of the observations are recorded in the table below.

Indicator	**Colour**
methyl red	yellow
phenol red	yellow
bromocresol green	blue
phenolphthalein	colourless
bromothymol blue	?

36. The pH of the rainwater and the predicted colour of the sample containing bromothymol blue are

A. 6.0 and blue
B. 7.6 and blue
C. 6.0 and yellow
D. 7.6 and yellow

37. When rain containing sulphurous acid falls into lakes containing dissolved calcium carbonate, the pH of the lake drops slightly and then remains relatively constant. Which of the following statements best describes a change that occurs in the lake water?

A. Carbonic acid is formed.

B. The calcium sulphite formed neutralizes the sulphurous acid.

C. The carbonate ion decomposes into carbon dioxide and water.

D. The formation of bicarbonate ion, $HCO_3^-{}_{(aq)}$, creates a buffer system with carbonate ion, $CO_3^{2-}{}_{(aq)}$.

Use the following information to answer the next two questions.

One component of acid rain can be formed in the atmosphere by the reaction

$$SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4(aq)} + 227.8\ kJ$$

38. As $SO_{3(g)}$ dissolves, acid rain

A. increases in pH and decreases in temperature

B. increases in pH and increases in temperature

C. decreases in pH and increases in temperature

D. decreases in pH and decreases in temperature

39. The molar heat of formation of $H_2SO_{4(aq)}$ in the atmosphere, under standard conditions, is

A. −453.7 kJ/mol

B. −586.7 kJ/mol

C. −814.0 kJ/mol

D. −909.3 kJ/mol

40. The pH of bottled lemon juice is best described as

A. greater than 7

B. equal to 7

C. $0 < pH < 7$

D. $7 < pH < 14$

41. A student added sodium hydroxide to a hydrochloric acid solution containing equal amounts of bromothymol blue and phenolphthalein indicator until the solution just turned a definite purple. The most likely pH at this end-point is

A. 10.0

B. 7.0

C. 7.6

D. 8.2

Use the following information to answer the next question.

pH of Blood	Effect
7.50	alkalosis (life threatening)
	↑
7.35	*healthy individual*
	↓
7.20	acidosis (life threatening)

42. Which of the following substances can be added to the blood of a young child with kidney disease in order to control acidosis?

A. $CO_{2(g)}$

B. $HCO_3^-{}_{(aq)}$

C. $H_2O_{(l)}$

D. $H_2CO_{3(aq)}$

---

43. The addition of $NaOH_{(aq)}$ would cause the equilibrium system $HBb_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+{}_{(aq)} + Bb^-{}_{(aq)}$ to turn

A. blue and the pH to decrease

B. blue and the pH to increase

C. yellow and the pH to decrease

D. yellow and the pH to increase

Use the following information to answer the next question.

Chemical Species

1 $HA^{3-}_{(aq)}$
2 $H_3A^{-}_{(aq)}$
3 $H_2A^{2-}_{(aq)}$
4 $H_4A_{(aq)}$

Numerical Response

11. As a solution of $NaOH_{(aq)}$ is continuously added to the acid $H_4A_{(aq)}$, a sequence of quantitative reactions occurs. The order in which the species listed above would react is _____ , _____ , _____ , and _____ .

(Record your **four-digit answer** in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

A student was asked to determine the concentration of an aqueous $HCl_{(aq)}$ solution by titrating it with 1.13 mol/L $NaOH_{(aq)}$ in the presence of bromothymol blue indicator. Since burets were not available, the student used droppers for each solution and assumed that each drop was of equal volume. It took 26 drops of $NaOH_{(aq)}$ to neutralize 20 drops of the $HCl_{(aq)}$ solution and to reach the bromothymol blue end-point.

Numerical Response

12. The concentration of the $HCl_{(aq)}$ solution was _____ mol/L.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

---

44. The main buffer solution of plasma and tissue fluid found in our bodies is $H_2CO_{3(aq)} - HCO_3^-{}_{(aq)}$. When excess hydronium ions enter our blood, the equation that represents the reaction that occurs is

A. $H_3O^+_{(aq)} + OH^-_{(aq)} \rightarrow 2\,H_2O_{(l)}$

B. $H_2CO_{3(aq)} + OH^-_{(aq)} \rightarrow HCO_3^-{}_{(aq)} + H_2O_{(l)}$

C. $H_2CO_{3(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + HCO_3^-{}_{(aq)}$

D. $H_3O^+_{(aq)} + HCO_3^-{}_{(aq)} \rightarrow H_2CO_{3(aq)} + H_2O_{(l)}$

The written-response questions follow on the next page.

Use the following information to answer the next question.

The Uranium-235 isotope is used as a fuel in some nuclear power plants. This isotope is used to enrich natural uranium ore. Prior to the enrichment process, the uranium ore, $UO_{2(s)}$, is converted to $UF_{6(s)}$. This conversion is represented by the following sequential equations.

Equation I $UO_{2(s)} + 4\,HF_{(g)} \rightarrow UF_{4(s)} + 2\,H_2O_{(g)}$

Equation II $UF_{4(s)} + F_{2(g)} \rightarrow UF_{6(s)}$

Written Response – 15%

1. **a.** Use molar heats of formation to calculate the amount of heat energy involved in producing 2.00 Mg of $UF_{6(s)}$ from natural uranium ore, $UO_{2(s)}$.

Molar Heats of Formation

Substance	ΔH_f° (kJ/mol)
$UO_{2(s)}$	–1129.7
$UF_{4(s)}$	–1914.0
$UF_{6(s)}$	–2112.9

b. Evaluate the use of nuclear energy for the generation of electricity. Include two reasons for and two reasons against the use of nuclear energy.

Written Response – 15%

2. A student predicts that the K_a value of a weak acid may be affected by the temperature of the acid solution. Given an acid of known concentration, design an experiment to test this prediction using commonly available laboratory apparatus.

Your response should include

- a procedure
- identification of controlled, manipulated, and responding variables
- indication of the calculations necessary to solve for K_a

You have now completed the examination.
If you have time, you may wish to check your answers.

No marks will be given for work done on this page.

Fold and tear along perforation.

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